Electrochemical Study of Interaction of Nickel and Alkaline Solutions

N. Wagner and G. Schiller*

German Aerospace Center (DLR), Institute of Technical Thermodynamics

Pfaffenwaldring 38-40, 70569 Stuttgart, Germany

**Corresponding author's email address: Norbert.Wagner@dlr.de*

Introduction

Nickel is an important material used as catalyst in electrochemical devices, e.g., as anode and cathode catalysts in alkaline electrolysers, as anode catalysts in alkaline fuel cells, in different batteries or as current collector grid in alkaline electrolyser. The reaction steps of heterogeneous electro-catalytic processes run at the solid-liquid interface. Therefore the understanding of the interaction of the electrolyte, especially of alkaline solutions, with the nickel surface is important. Depending on the technical application, Ni and different Ni alloys are used and therefore different oxide films are formed on the metal surface. To reduce the performance losses of the electrochemical device given by the low conductivity of such oxide films, much attention was paid to the understanding of conduction mechanism of oxide films. The conductivity of nickel oxide surfaces is influenced by the thickness of the oxide layer, chemical composition of the oxide layer, and gradients of the composition, depending on the applied potential and composition (purity) of the electrolyte. In particular, the influence of different contents of chloride ions (10 ppm, 100 ppm and 500 ppm) in the alkaline solution (10 N NaOH) was investigated.

Experimental

For the investigation of the electrochemical behaviour of nickel electrodes in 10 N NaOH with different Cl^- content at 85°C, a polished rotating disk nickel electrode (>99,2% Ni) with 1 cm^2 geometric surface was used (Fig.1). The used counter electrode was a platinum foil and a RHE (gaskatel) as reference electrode.

Fig.1: Experimental set-up for the electrochemical characterisation of Ni-electrodes in alkaline solution

A first characterization of the Ni electrode was performed using cyclic voltammetry (CV) in the potential range from open cell potential (OCP) up to 1.5 V and down to 0 V with a scan rate of 100 mV/s.

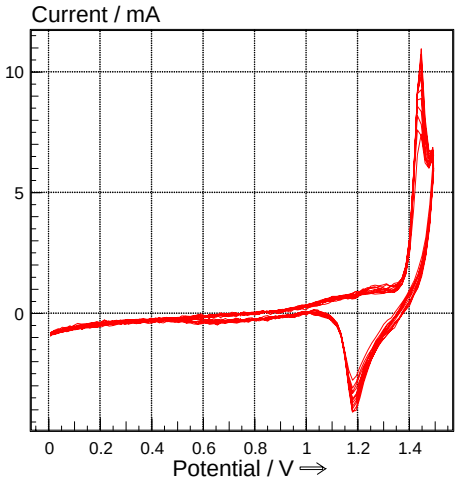

Fig.2: CV (10 runs) of Ni electrode in 10 N NaOH at 85°C, 100 mV/s from 0 V to 1.5 V

In addition, electrochemical impedance spectra (EIS) at OCP and impedance series measurements (18 spectra) over 3 h at 1.15 V in the frequency range from 50 mHz to 100 kHz were measured.

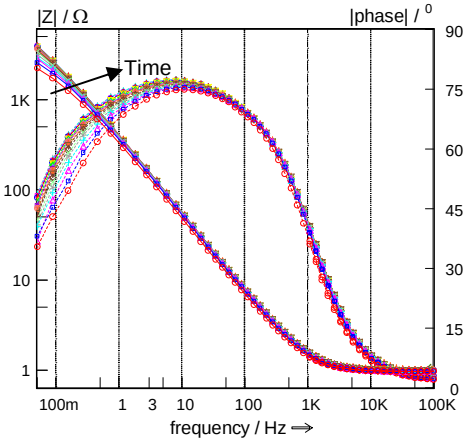

Fig.3: Bode diagram of EIS series (18 spectra) measured on Ni electrode in 10 N NaOH+10 ppm Cl^- at 1.15 V during 3 h at 85°C

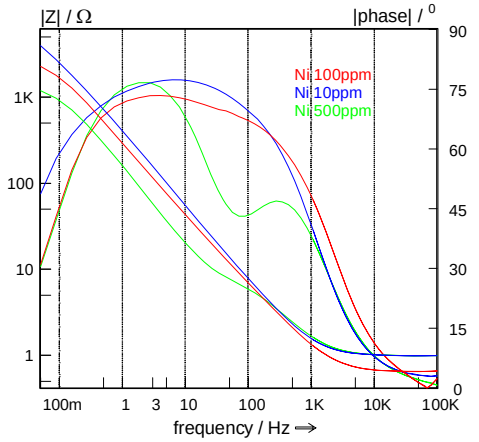

Fig.4: Bode diagram of EIS (18th spectra, after 3 h) measured on Ni electrode in 10 N NaOH and different Cl^- concentrations at 1.15 V, 85°C

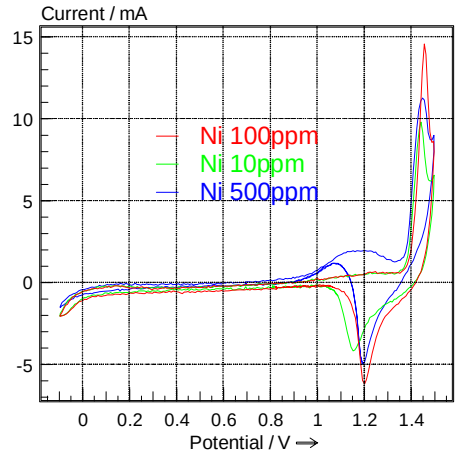

Fig.5: CV (last from 10 runs) of Ni electrode in 10 N NaOH and different Cl^- concentrations at 85°C, 100 mV/s from -0.1 V to 1.5 V

Conclusions

From the impedance spectra represented in Fig. 4 one can see that with increasing Cl^- content in the electrolyte the impedance modulus in the low frequency range decreases, corresponding to an increase of the corrosion current. The same conclusion can also be drawn from Fig. 5, proving that the addition of Cl^- ions enhances the formation of an oxide layer, especially in the potential range between 1 V and 1.4 V (Fig.5).

Acknowledgement: Financial support by the German Federal Ministry of Education and Research (BMBF) through 01LS05007 is gratefully acknowledged.